

# Development of a Global Hydrographic Climatology with High Quality Arctic Data

Michael Steele

Polar Science Center, Applied Physics Laboratory, University of Washington  
1013 NE 40th St., Seattle, WA 98105, U.S.A.  
phone: (206) 543-6586      fax: (206) 616-3142      email: [mas@apl.washington.edu](mailto:mas@apl.washington.edu)  
Award Number: N00014-99-1-0780  
<http://psc.apl.washington.edu/Climatology.html>

## LONG TERM GOALS

My long term goal is to quantify the spatial and temporal variability of the Arctic Ocean hydrographic structure. A related goal is a better representation of this variability in numerical models.

## OBJECTIVES

The objective of this project was to create a monthly mean climatology of ocean temperature and salinity that will be useful as the Navy updates its Polar Ice Prediction System (PIPS) Arctic model. The climatology will be used for model initialization and validation, as well as for climate restoring as this is deemed necessary. The PIPS model domain extends well outside of the Arctic Ocean proper and thus requires an accurate ocean data set that spans both Arctic and non-Arctic regions, something that did not exist before this project began.

## APPROACH

Two data sets were used as inputs to an optimal interpolation scheme: (i) the global World Ocean Atlas (WOA'94; *Levitus and Boyer*, 1994) and (ii) the regional Arctic Ocean Atlas (AOA; *EWG*, 1997 & 1998). The AOA consists of formerly classified and otherwise unavailable data from both Russian and western sources that serve to fill a data gap in the WOA'94. **Figure 1** illustrates the WOA'94 data gap with respect to winter season surface salinity. Our approach was to provide to the Navy an "updated WOA product" that would be as close as possible to the original WOA everywhere but in the arctic seas. This also means that we have used the WOA data file structure.

Each data set requires preprocessing before it is ready for merging. The WOA'94 data are provided on a monthly average  $1 \times 1$  degree latitude/longitude grid. We discarded  $1 \times 1$  degree pixels north of  $65^\circ\text{N}$  if they contained fewer than 2 observations. Temperature pixels were also discarded if they were below freezing. The AOA data are provided on a seasonal (winter and summer) average 50 km cartesian grid with fewer vertical levels than the WOA'94 data. Since our goal is to create an "updated WOA," we first interpolated AOA data vertically to WOA'94 levels. The next step was to create synthetic monthly AOA data, since the AOA comes only as seasonal averages. We fit sine waves at each AOA grid point to create an annual cycle, with the original seasonal means providing the extrema in winter and summer.

| Report Documentation Page  |                                   |                                    |   | Form Approved<br>OMB No. 0704-0188                  |                                 |
|--|-----------------------------------|------------------------------------|---|---|---------------------------------|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. |                                   |                                    |   |   |                                 |
| 1. REPORT DATE<br><b>30 SEP 1999</b>   |                                   | 2. REPORT TYPE                     |   | 3. DATES COVERED<br><b>00-00-1999 to 00-00-1999</b> |                                 |
| 4. TITLE AND SUBTITLE<br><b>Development of a Global Hydrographic Climatology with High Quality Arctic Data</b>   |                                   |                                    |   | 5a. CONTRACT NUMBER                                 |                                 |
|  |                                   |                                    |   | 5b. GRANT NUMBER                                    |                                 |
|  |                                   |                                    |   | 5c. PROGRAM ELEMENT NUMBER                          |                                 |
| 6. AUTHOR(S)   |                                   |                                    |   | 5d. PROJECT NUMBER                                  |                                 |
|  |                                   |                                    |   | 5e. TASK NUMBER                                     |                                 |
|  |                                   |                                    |   | 5f. WORK UNIT NUMBER                                |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>University of Washington, Applied Physics Laboratory, 1013 NE 40th Street, Seattle, WA, 98105</b>   |                                   |                                    |   | 8. PERFORMING ORGANIZATION REPORT NUMBER            |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)  |                                   |                                    |   | 10. SPONSOR/MONITOR'S ACRONYM(S)                    |                                 |
|  |                                   |                                    |   | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)              |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release; distribution unlimited</b>  |                                   |                                    |   |   |                                 |
| 13. SUPPLEMENTARY NOTES  |                                   |                                    |   |   |                                 |
| 14. ABSTRACT   |                                   |                                    |   |   |                                 |
| 15. SUBJECT TERMS  |                                   |                                    |   |   |                                 |
| 16. SECURITY CLASSIFICATION OF:  |                                   |                                    | 17. LIMITATION OF ABSTRACT<br><b>Same as Report (SAR)</b> | 18. NUMBER OF PAGES<br><b>4</b>                     | 19a. NAME OF RESPONSIBLE PERSON |
| a REPORT<br><b>unclassified</b>  | b ABSTRACT<br><b>unclassified</b> | c THIS PAGE<br><b>unclassified</b> |   |   |                                 |

A standard optimal interpolation procedure was used to merge these two monthly data sets. Error variances were chosen to minimize changes to the WOA'94 outside of the arctic domain. Within the domain, the more densely spaced AOA data were assigned higher weight. A constant length scale of 1000 km over the globe was used.

The work described in this report was performed in collaboration with a young programmer here at the Polar Science Center, Rebecca Morley, who has recently left to pursue other interests. She will be succeeded by Wendy Ermold, a part-time graduate student in physics at the University of Washington.

## **WORK COMPLETED**

We completed the merging procedure for the monthly product. Web pages were created that describe the procedure and allow downloading of the data (see <http://psc.apl.washington.edu/Climatology.html>). A paper is now in preparation for submittal as a note to *J. Climate*.

## **RESULTS**

The result of this merging is a product we call the Polar science center Hydrographic Climatology (PHC). An example is shown in Figure 1 for winter mean surface salinity. The original WOA'94 picture (not shown) predicts unrealistic areas of very fresh water which are caused by a lack of winter data and various numerical errors. These are eliminated in the PHC. The PHC now consists of climatological mean annual, seasonal, and monthly fields of temperature and salinity over the entire globe that include an excellent description of the arctic seas.

I have received additional ONR funding to continue this project on a number of fronts. Our first task will be to update the mean fields using the new WOA'98, which still suffers from a lack of data in the Arctic regions but has superior properties in much of the rest of the global ocean. The next step will be to create climatological fields of hydrographic variance, an exciting project that will allow us to better define the significance of differences between PIPS model output and the climatology. We will also begin such model-data comparison as soon as PIPS model output are available for this purpose, using temperature-salinity analysis as well as more straightforward horizontal and vertical sections.

## **IMPACT/APPLICATIONS**

The PHC is the first global ocean climatology that includes a good description of the Arctic Ocean. As such, it will be useful for a variety of modeling and observational studies.

## **TRANSITIONS**

PIPS modelers have downloaded the data and have begun using it in model development (D. Stark, Naval Postgraduate School, personal communication). The PHC data set is useful for any ocean GCM (global climate model) wherein an accurate Arctic Ocean is desired. As such, PHC data have been downloaded by about 20 users from around the world at this time.

## **RELATED PROJECTS**

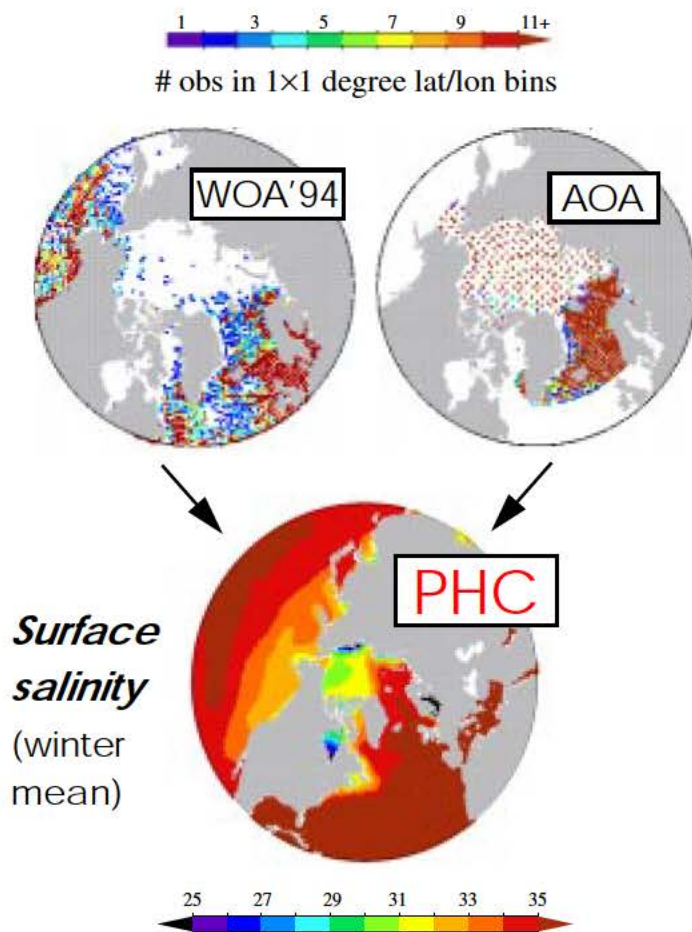
1 - We will use PHC data to validate the Climate System Model (CSM) at the National Center for Atmospheric Research (NCAR), work funded by NSF.

2 - We hope to use the PHC to validate models that assimilate satellite observations, work proposed to NASA.

## **REFERENCES**

Environmental Working Group (EWG), Joint U.S.-Russian Atlas of the Arctic Ocean [CD-ROM], Natl Snow and Ice Data Cent, Boulder, Colo., Web Site: <http://ns.noaa.gov/atlas.>, 1997 & 1998.

Levitus, S. and T. Boyer, NOAA Atlas NESDIS: *World Ocean Atlas 1994*, US Dept. of Commerce, NOAA/NESDIS, Washington, DC, 1994.



## The **P**olar science center **H**ydrographic **C**limatology

Michael Steele

*University of Washington*

A merging of the global World Ocean Atlas (WOA'94) and the regional Arctic Ocean Atlas (AOA) gridded temperature & salinity fields using optimal interpolation.

- What we have now:

Global 3D annual, seasonal, and monthly fields of T & S in the same (NODC) data format & (x,y,z) grid as the WOA'94.

- Further PIPS work:

- ◆ update to WOA'98
- ◆ model - data comparison & validation
- ◆ T-S analysis
- ◆ variance maps

<http://psc.apl.washington.edu/Climatology.html>

Funding provided by  
ONR (PIPS) and NASA (EOS).